

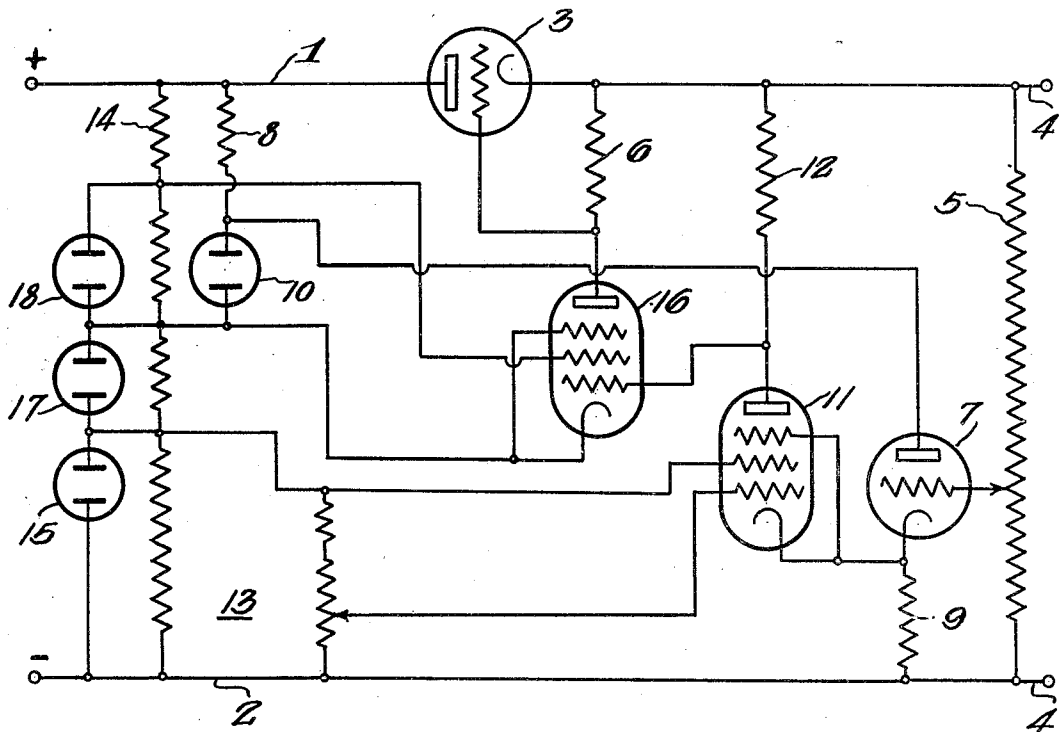
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REGULATING SYSTEM

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REGULATING SYSTEM

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This invention relates to regulating systems such as are utilized to regulate the voltage or current of a load circuit, and has for its principal object the provision of an improved system and method of operation whereby very close regulating of the desired characteristic is effected without the contact resistance degeneration and power losses encountered where the cathode potential of the initial control channel device is derived from the load circuit potentiometer.

In systems of this character, it has been proposed to derive from a resistor connected in shunt to the load circuit a regulating potential which is applied through a control channel to the control grid of a regulating device having its cathode-anode circuit connected in series with the load. This control channel usually includes one or more amplifiers and functions to maintain at the regulating device control grid a potential which opposes variations in the load circuit voltage, thereby maintaining the load voltage variations within narrow limits.

It has been proposed to impress a fraction of the load voltage in series with a source of bias potential between the cathode and control grid of the first tube in the control channel. This type of connection has the disadvantage that variations in the voltage derived from the shunt connected resistor are likely to produce erratic variations in the regulated output due to corrosion of the contacts, especially if the cathode-anode current of the control channel is large with respect to the current of the shunt-connected resistor.

Thus, in the operation of this prior art system, the control voltage derived from shunt resistor is applied to the cathode of the first control channel tube, the grid of this tube being maintained at a fixed positive voltage with respect to the negative end of the load circuit. In this connection, the plate current of the tube flows through the sliding contact of the resistor, and through the lower portion of the resistor to the negative terminal. Corrosion of the contacts and consequent erratic variation in the regulated output are likely to result if the plate current is very large relative to the current through the resistor. Also, the resistor section through which the plate current of the first control tube flows causes a degenerative action which reduces the accuracy with which the circuit regulates the output voltage, especially if the resistor has a high resistance. For both these reasons, it is preferable that the resistor be small enough to carry a large current in comparison with the current

through the first control channel tube. This occasions a considerable waste of power, which might be large compared with the power consumed in the load.

In accordance with the present invention, the disadvantages of the arrangement considered above are eliminated by the interposition of a control tube between the shunt resistor and the cathode of the control channel amplifier. As will appear, the initial regulating device functions to transfer load circuit voltage variations to the cathode of a following control amplifier without change in phase or amplitude, and these voltage variations, after suitable amplification, are applied to the control circuit of the regulating device in such a way as to maintain the variations within narrow limits.

The invention will be better understood from the following description considered in connection with the accompanying drawing and its scope is indicated by the appended claims.

The single figure of the drawing is a wiring diagram of the regulating system arranged in accordance with the invention.

This system includes supply terminals 1 and 2 from which current is supplied through a cathode-anode circuit of a regulating device 3 to a load circuit 4 provided with a shunt-connected potentiometer 5. The regulating tube 3 is provided with a control grid circuit which includes a resistor 6, the potential drop of this resistor being applied to the regulating tube control grid.

For regulating the potential of the resistor 6 in response to variation in the voltage of the load circuit, there is provided a control channel including a control tube 7 which derives its control grid potential from the load circuit potentiometer 5 and which is connected between the terminals 1 and 2 through an anode resistor 8 and a cathode resistor 9, a glow tube 10 being provided for stabilizing the anode potential of the control device 7. The potential of the resistor 9 is applied to the cathode and suppressor grid of a control amplifier 11 which derives its cathode-anode potential through the resistor 9 and a resistor 12 and is provided with a control grid adjustably connected to a resistor network 13 and with a screen grid connected between the third and fourth sections of a resistor 14, a glow tube 15 being provided to stabilize the screen grid voltage of the amplifier 11.

The control channel also includes an amplifier 16 which derives its cathode-anode voltage through the resistor 6 and the lower two sec-

tions of the resistor 14 and has its cathode voltage stabilized by a glow tube 17. Potential is applied to the control grid of the amplifier 16 through a terminal connected at the junction of the resistor 12 and the anode of the amplifier 11. Screen grid potential is applied to the amplifier 16 from a terminal intermediate the first and second sections of the resistor 14, and this screen grid potential is stabilized by a glow tube 18.

Under these conditions there is applied to the control grid of the device 7 a potential dependent on the voltage of the load circuit 4 with the result that the potential drop of the resistor 9 corresponds in phase and amplitude to the load circuit voltage variations.

Since the cathode of the amplifier 11 is connected to the upper terminal of the resistor 9, the voltage of this cathode varies in accordance with the potential drop of this resistor; the potential drop of the resistor 12 is correspondingly varied and is applied to the control grid of the amplifier 16 and functions to produce at the lower terminal of the resistor 6 and at the control grid of the regulating device 3 an amplified potential corresponding to the potential applied to the control grid of the device 7.

Thus, if the load voltage tends to increase, the control grid of the device 7 becomes more positive, the cathode of the device 11 becomes more negative due to the drops of the resistors 8 and 9, less current is transmitted through the resistor 12, the control grid of the device 16 becomes more positive, more current is transmitted through the resistor 6 and the control grid current of the device 3 becomes more negative, thus preventing further change in the load circuit voltage and maintaining such change within narrow limits. A decrease in load circuit voltage, of course, produces an action the opposite of that just described.

More specifically stated, the operation of tube 7 is as follows: Its cathode is connected to the negative end of the circuit through the resistor 9, by virtue of which the cathode is maintained at a positive potential. Constant plate voltage is supplied from the junction of the regulator, lamp 10 and the resistor 8, the latter serving to reduce the voltage to a suitable value, which is held constant by the lamp 10, which is a cold-cathode gas-filled discharge tube of the kind commonly used for voltage regulation. The grid of the tube 7 is biased positively (with respect to the negative end of the load) by the voltage at the sliding contact on 5. Now since the effective grid bias of 7 (i. e. the voltage between cathode and grid) depends on the current flowing through 9, and since the current flowing through 9 depends on the effective grid bias, the grid bias and the plate current will automatically adjust themselves to an equilibrium condition in which the grid bias has the correct value to allow just enough plate current to flow to maintain the grid bias. This equilibrium ordinarily occurs when there is an effective negative grid bias, which will, however, be quite small (a few volts or even less than 1 volt) if the tube 7 has a high amplification factor. Thus, the cathode of 11 is maintained at substantially the voltage applied to the grid of 7, and if for any reason the voltage on the grid of 7 fluctuates or is altered, the cathode of 11 suffers a corresponding change. The voltage at the cathode of 11 behaves as it would if it were directly connected to the sliding contact of the resistor 5, and since there is no grid current, the resistor 5 may have

high resistance and consequently consume very little power. Degenerative effects due to passage of the cathode current of the amplifier 11 through the potentiometer are eliminated. Corrosion of the sliding contact will not occur because there is no current flowing through it and even if there were corrosion it would have no effect because it would not affect the voltage applied to the grid of 7.

Additional voltage regulator tubes 15, 17, 18 are supplied for the purpose of maintaining the cathode of 16 and the screen grids of 11 and 16 at constant voltages.

Positive voltage for the grid of tube 11 is supplied by a tap on the resistor 13, which is connected across the regulator lamp 15. This grid voltage may be adjusted in addition to, or instead of, adjustment of the sliding contact on 11, for the purpose of altering the voltage supplied to the load.

I claim as my invention:

1. The combination of current supply terminals, a regulating device provided with cathode-anode and control grid circuits, a load circuit connected to said terminals through said cathode-anode circuit, an impedance device, a second impedance device, a control device provided with a control grid and with an anode connected to one of said terminals through said impedance device and a cathode connected to another of said terminals through said second impedance device, means for applying to said control device grid a potential dependent on and lower than the voltage of said load circuit including a variable potentiometer connection for said control grid with said load circuit and a circuit for establishing a state of equilibrium between grid-cathode voltage and anode current in said control device which varies with variations in voltage at said supply terminals, and means for applying to said regulating device control grid circuit a potential dependent on the potential drop of said second impedance device, said last named means including an amplifier tube having a cathode connected to the cathode end of said second impedance device, a control grid connected to the opposite end of said second impedance device, a bias potential supply device in said last named connection, and an anode coupled to said control grid circuit.

2. The combination of current supply terminals, a load circuit, a regulator tube having an anode-cathode space path connected serially between one of said terminals and the load circuit, a vacuum tube amplifier provided with a cathode-anode circuit connected across said load circuit and with a control grid circuit, means for deriving from said load circuit a potential to be amplified, and means including an electron discharge device provided with a control grid circuit arranged to be subjected to said potential and with a cathode-anode circuit arranged to maintain the cathode of said amplifier substantially at said potential.

3. The combination of direct current supply terminals, a regulating device provided with cathode-anode and control grid circuits, a load circuit connected to said terminals through said cathode-anode circuit, said load circuit having a positive terminal connected with the cathode end of said cathode-anode circuit and having a negative terminal connected with the negative current supply terminal, a potentiometer connected in shunt with said load circuit, a control device comprising an amplifier tube having a con-

5 trol grid variably connected with said potentiometer and having a cathode connected with the negative current supply terminal, a potential drop producing impedance device connected in circuit
10 between said cathode and said negative terminal, said control tube having an anode connected with the positive current supply terminal, a controlling resistor in said connection, an amplifier tube having a cathode connected with the cathode of said control tube and having an anode connected with the load circuit to receive anode current therefrom, means for coupling said anode to the control grid circuit of said regulating device to apply a controlling potential thereto in a sense to provide regulation of the load potential, and means providing a grid circuit for said amplifier tube including a bias potential supply device and said potential drop producing impedance device in series.
20 4. The combination of positive and negative direct current supply terminals, a load circuit including a shunt connected potentiometer device having positive and negative terminals, a regulator device interposed between said load circuit and the positive supply terminal and comprising an amplifier tube having an anode connected with said positive supply terminal, a cathode connected with the positive terminal of said potentiometer device and having a control grid,

a control tube having an anode connected with the positive supply terminal, an amplifier tube having an anode connected with the positive terminal of said potentiometer device, said last named anode being coupled with said control grid of the regulating device to apply a controlling potential thereto in a sense to provide regulation of the load potential, said control and amplifier devices each having a cathode connected to the negative supply terminal and to the negative terminal of said potentiometer device, a potential drop producing impedance device in said connection common to both cathodes, a control grid for said control device having a variable connection with said potentiometer, whereby a positive potential may be applied to said control grid in opposition to a positive potential applied to the cathode of said control device from said potential drop producing impedance device to establish a state of equilibrium in the anode current flow through said control device corresponding to a predetermined load circuit potential, a second potentiometer device connected between said direct current supply terminals, a control grid for said amplifier, and means providing a variable connection on said last named potentiometer for said last named control grid.

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